PHYSICS 101/105: Introduction to Astronomy and Astronomy Laboratory
Wisconsin Lutheran College
Fall 2019

Introduction

What is our place in the universe? This course provides an introduction to the sciences of astronomy and cosmology. We will study a wide range of texts written by ancient thinkers such as Aristotle and Ptolemy, reformation-era thinkers such as Copernicus and Kepler, and modern thinkers such as Hubble, Einstein and Lemaitre.

Instructor information and class times

Kerry Kuehn, Ph.D.
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Class room: S113 (Generac Hall)
Class time: MWF 8:00 - 8:50 a.m.

Grade components

Classroom Discussion	15%	Midterms	20% (each)
Homework Assignments	15%	Comprehensive final exam	30%
		Astronomy observation notebook	(for PHY 105)

Grading scale

A	100-93%	C	74-70%
AB	92-88%	CD	66-62%
B	87-80%	D	61-54%
BC	79-75%	F	53-0%

General Course objectives

- understand nature—(specifically the sciences of astronomy and cosmology)
- improve reading comprehension and vocabulary—(through the reading and discussion of great texts)
- discern truth from error—(by analyzing and comparing the best ideas which have been written)
- articulate scientific ideas—(both verbally and in written form)
- solve problems—(conceptual, mathematical, experimental)
- provide a suitable foundation for advanced coursework in physics (talk to me about major or minor)

Specific Course objectives

In this course the student will learn how to

- identify the astronomical significance of key dates marking the seasons (*e.g.* vernal equinox, summer solstice)
- calculate the altitude of the sun at its zenith on key dates
- identify constellations and predict the motion of the sun through the zodiac
- predict the position of the moon within the zodiac based on its phase and the position of the sun
- learn how astronomical instruments are used to measure the locations and sizes of celestial bodies
- maintain a clear and well-organized astronomy observation notebook
- describe the motion of the four visible planets using both a geocentric and a heliocentric world-view
- evaluate Copernicus' rationale for a heliocentric world-view, as well as counter-arguments
- explain Kepler's three laws of planetary motion and the Newtonian theory of gravity
- critically analyze ancient, modern and contemporary cosmological theories
- recognize and evaluate both theistic and atheistic arguments rooted in astronomy and cosmology

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Bibliography

Required textbook:

- Kerry K. Kuehn, Physics: A Student's Guide through the Great Texts, Volume I: The Heavens and the Earth. Springer (2015). ISBN-978-1-4939-1360-2

Suggested books:

- Roger Sinnott, Sky & Telescope's Pocket Sky Atlas. Sky Publishing (2006). ISBN-10 1931559317.
- Observer's Handbook 106 edition. Royal Astronomical Society of Canada (2013). ISBN-10 1927879000.
- Tom VanDamme and David Harriman, Astronomy Book 3: Seasons and the Celestial Sphere. Falling Apple Science Institute (2012).

Suggested software/apps

- Luminos. Tablet stargazing software by Wobbleworks LLC.
- Stellarium. Desktop planetarium softward by Matthew Gates and Barry Gerdes.

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Examinations

There will be three examinations in this class. To best prepare for the exams, you should

(1) read all of the *assigned reading* selections completely—(at *least* once),
(2) use the *study guide* after each reading—(to be sure you understand key points in the readings),
(3) participate in *classroom discussions*—(use our classroom discussion to figure out what you don't understand in the readings)
(4) work through the recommended *homework exercises*—(*before* resorting to the posted solutions),
(5) *study the solutions* to the exercises—(to be sure you don't make the same mistakes twice),
(6) learn the *vocabulary words*—(to help with reading comprehension and overall literacy),
(7) regularly *visit me* during office hours to discuss physics—(I am a very nice person)

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Reading and discussing the great texts

In this course, we will read and discuss some of the classic scientific texts dealing with astronomy and cosmology. The scientific texts we will read are considered classics because they address timeless questions in a particularly honest and convincing manner. This does not mean that everything they say is true. In fact many classic scientific texts contradict one another. But it is by the careful analysis of the most reputable observations and opinions that one may begin to discern truth from error.

You will not understand everything you read; nobody does. The texts are challenging. Like great literature, these texts must be ``grown into", so to speak. (Remember: nobody understands all of Shakespeare or all of the Bible the first time they read it, either!) So think of this course as a ``first dip" into the deep end of the pool. These texts are classics because—like fine wine—both the beginner and the advanced scholar can profit by studying them.

The time that we spend in the classroom will be devoted to discussing the reading selections. As the discussion leader, I will typically ask questions regarding specific ideas which are found in the texts. For instance, I may ask, "How far away is the plane Venus?" or "Has it always been at that distance?" And if so, "How do you know?" The task will then be to try, as a group, to answer these questions.

It is critical that participants carefully read the assigned selections before engaging in discussion. This will help participants to make relevant comments and to cite textual evidence to support or contradict assertions made during the course of the discussion. In this way, many assertions will be revealed as problematic, in which case they must then be refined or rejected altogether. This is precisely the method used by scientists themselves in order to discover and evaluate competing ideas or theories.

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Classroom discussion: étiquette and grading

During our discussion, you may speak with complete freedom. There is only one rule: *any comment or question you make must be made publicly so that all others can hear and respond*.

Each student will receive a discussion grade for the class which will range from 0% to 100%. I will notify you of your discussion grade when I return each midterm exam. To clarify how I approach classroom discussion grading, consider the following examples.

- The 100% student is actively engaged in the classroom discussion. His or her ability to raise interesting and relevant points from the text is evidence that they have studied the assigned text and put significant thought into analysis outside of class.
- The 80% student is somewhat engaged in the classroom discussion. He or she makes comments or raises questions during the discussion, but they have some trouble providing specific textual or rational support for their assertions.
- The 60% student is very occasionally engaged in the classroom discussion. They sit silently but politely. They may have read the assigned text, but have not thought enough about it to formulate any coherent thoughts. They uncritically accept whatever is said by the author, the instructor and the other students in the class.
- The 0% student comes to class, but instead of presenting his or her views to the class publicly, they whisper them to their friends. The instructor and other students find this distracting and a bit rude.

From an instructor's perspective, discussion is admittedly the most difficult grade to assign, as it is unavoidably somewhat subjective. Nonetheless, learning to verbally articulating scientific ideas in a public setting is an important skill and one of the secondary learning objectives of this course.

Most students are initially apprehensive about engaging in public discussion. This is natural. If you find yourself to be one of these it is important to realize that you do not need to make an elaborate point in order to engage in classroom discussion. Often, a short question can provide a simple avenue. For example, ``I am unclear what the author means by the term *celestial*. Can someone please clarify?" Write down questions like these in the margins while reading the text. Start like this. Pretty soon, you may find yourself joining gamely in classroom discussion.

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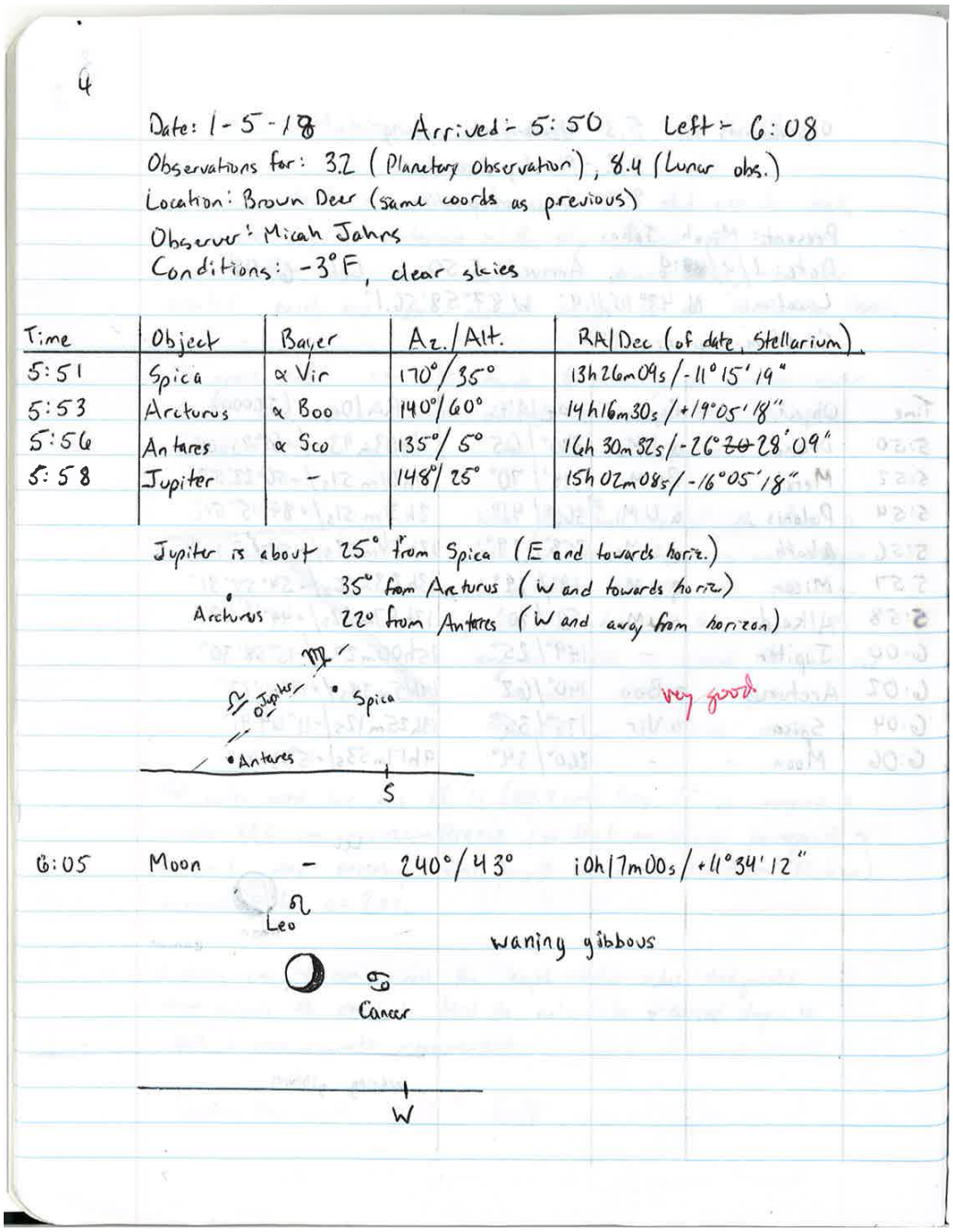
Astronomy notebook (PHY 105)

You must keep a dedicated astronomy notebook containing your laboratory exercises and observations for this course. Each exercise should begin on a new page. You should reserve the first few pages in your notebook for a table of contents, and the notebook pages should be numbered. Notebook grades will be determined based on how clear, neat, correct, and convincing your writing and thinking are.

Observations which are recorded in your notebook should contain:

- Your name and the names of all others present during the observation
- The location, date and time of arrival and departure on site
- The viewing conditions, such as sky transparency, weather, and local lighting environment (if outdoors)
- For each object viewed: date and time of observation, the designation, name and type of object, the constellation, and the make and model of telescope or other viewing aid used.
- Any additional thoughts or analysis that seems appropriate (or required by the instructor)

A sample page from a student's observation notebook is provided at the end of this syllabus.



4

Date: 1-5-18 Arrived: 5:50 Left: 6:08
Observations for: 3.2 (Planetary observation), 8.4 (Lunar obs.)
Location: Brown Deer (same coords as previous)
Observer: Micah Jahrs
Conditions: -3°F, clear skies

Time	Object	Bayer	Az./Alt.	RA/Dec (of date, Stellarium)
5:51	Spica	α Vir	170°/35°	13h26m09s/-11°15'19"
5:53	Arcturus	α Boo	140°/60°	14h16m30s/+19°05'18"
5:56	Antares	α Sco	135°/5°	16h30m32s/-26°~~20~~28'09"
5:58	Jupiter	–	148°/25°	15h02m08s/-16°05'18"

Jupiter is about 25° from Spica (E and towards horiz.)
35° from Arcturus (W and towards horiz)
22° from Antares (W and away from horizon)

Arcturus
Jupiter
Spica
Antares
S

very good!

6:05 Moon – 240°/43° 10h17m00s/+11°34'12"

Leo
Cancer
waning gibbous
W

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Final thoughts

I want to encourage you to come to me with any concerns you may have during the course of the semester, whether they be physics questions or difficulties with reading or discussion. This course is designed to challenge you, but not to “break” you. Reading the classics in any field is challenging, but very rewarding. I would very much like to help you succeed and to enjoy this class! My contact information is listed at the beginning of this syllabus, so please feel free to contact me!

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Week 1 (Aug. 26, 28, 30)		
	Day 1.1	Welcome! Go over syllabus. Learning to stargaze with Stellarium software.
		Assignment: Download and install Stellarium software on your personal computer. Spend at least half an hour exploring the various tabs and functions and observing the motion of the sky.
		Laboratory: How to keep a laboratory/observation notebook. Assemble Horizon Globe. Do exercises with Horizon Globe beginning with "Day and Night" through "Using the Moon and Planet Calendar" (the grey and yellow sections in Tom VanDamme's *Basic Astronomy* manual.)
	Day 1.2	The sun, the moon and the planets (the sun's motion; the moon's phases; the motion of Mercury, Venus, Mars, Jupiter and Saturn)
		Assignment: Spend half an hour looking at the motion of the sun, the moon, and the planets on Stellarium. Be sure your location is set to Milwaukee and use the date and time window to increment time in hours, days, and months while observing their positions.
	Day 1.3	The stars: how to use guidepost constellations (Orion, The Big Dipper, Cygnus, and Cassiopeia) and the four stories (Orion's hunting party, a dipper for a damsel in distress, Cygnus happens upon a battle, and the queen goes fishing) to find your way around the night sky.
		Assignment: Before the next class period (Day 2.2) (a) Use the four stories worksheets to practice identifying constellations and bright stars. (b) Spend a half an hour outside after dark trying to identify as many constellations as you can using the guidepost constellations and the four stories. (c) Try to find Jupiter and Saturn (hint: In Aug. 2019, they are both visiting the battle between Scorpius and Sagittarius).
Week 2 (Sep. 2, 4, 6)		
	Day 2.1	Labor day (no class)
		Assignment: Use the four stories worksheets to practice identifying constellations and bright stars *until you know them perfectly*.
		Laboratory: none.
	Day 2.2	Introductory comments on Aristotle and ancient Greek astronomy. Begin reading Aristotle's *On the Heavens* in class together.
		Assignment: Finish reading *Nature, Number and Substance* (ASG Chap. 1). Type an essay on Science and Speculation (Ex.1.1). This essay will be due on day 3.1. It should be single-spaced, use 12 point font, and should have correct spelling, grammar and punctuation. It should be *no longer* than one page. You should also include a correctly formatted citation in Chicago style at the bottom of the page referring to the source reading.
	Day 2.3	Discuss ASG Chap. 1 in class. Introduce the celestial sphere and discuss how it can be used to understand the motion of the sun, the moon, and the planets.
		Assignment: (a) Read *The Shape and Motion of the Heavens* by (ASG Chap. 2) and consider the study questions. (b) Ask someone to read and check your essay assignment that is due on day 3.1 to be sure it is well-done and that it reflects clear and correct thinking.
Week 3 (Sep. 9, 11, 13)		
	Day 3.1	Discuss ASG Chap. 2. Talk about how the celestial sphere can be used to understand the seasons of the year.
		Assignment: Read *The Earth at the Center of the World* (ASG Chap. 4.)

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		Laboratory: Do exercises with Horizon Globe beginning with "Constellations" and ending with "What's Next" (the red, green and purple sections in *Basic Astronomy* by Tom VanDamme).
	Day 3.2	Discuss ASG Chap. 4. Introductory comments on Ptolemy's *Almagest.*
		Assignment: Read *The World of Ptolemy* (ASG Chap. 5) and consider the study questions.
	Day 3.3	Discuss ASG Chap. 5; focus on how Ptolemy argues for an earth-centered world-view.
		Assignment: Type an essay on *The Shape of the Earth* (Ex. 5.2). This essay will be due on day 4.1. It should be single-spaced, use 12 point font, and should employ correct spelling, grammar and punctuation. It should be no longer than one page. Again, you should also include at least one correctly formatted citation in Chicago style at the bottom of the page.
Week 4 (Sep. 16, 18, 20)		
	Day 4.1	Introduce celestial coordinate systems (horizontal, equatorial, ecliptic), Bayer designations of stars and stellar magnitudes.
		Assignment: Read *Geometrical Tools* (ASG Chap. 7) and think about the study questions.
		Laboratory: *Building a cross-staff* (Ex. 7.5). Your cross-staff will be used during the month of October, when you will do *Lunar Observations* (Ex. 8.4).
	Day 4.2	Discuss ASG Chap. 7 and how astronomical tools can be used to determine the length of the year.
		Assignment: Do *The Sun at Zenith* (Ex. 7.1) and *Altitude of the Sun* (Ex. 7.2). These will be due in class on day 4.3.
	Day 4.3	Go over exercises 7.1 and 7.2. Lecture on the history of calendar construction based on astronomical measurements.
		Assignment: Read *The Sun, the Moon and the Calendar* (ASG Chap. 8) and think about the study questions.
Week 5 (Sep. 23, 25, 27)		
	Day 5.1	Discuss ASG Chap. 8, especially Bede's challenging Chap. 25, in which he explains *When and why the moon appears to be facing upwards, downwards, or standing upright*.
		Assignment: (a) Do *The Moon and the Zodiac* (Ex. 8.1) and *Crescent Moon* (Ex. 8.2). (b) Reading on the cosmological argument and medieval Arabic astronomy.
		Laboratory: Finish up Horizon Globe exercises. Do *Spherical Astrolabe* (Ex. 7.3).
	Day 5.2	Go over Ex. 8.1 and 8.2. Discuss the relationship between astronomy and theology; the Al-Ghazali's cosmological argument for the existence of God.
		Assignment: Read *From Astronomy to Cartography* (ASG. Chap. 9)
	Day 5.3	Discuss ASG Chap. 9 on the relationship between astronomy and cartography.
		Assignment: Do *Latitudes* (Ex. 9.1) and *Waldseemueller's World View* (Ex. 9.2). Due on Day 6.1
Week 6 (Sep. 30, Oct. 2, 4)		
	Day 6.1	Go over Ex. 9.1 and 9.2.
		Assignment: Study for exam.
		Laboratory: *Latitude and longitude observations* (Ex. 9.3). This involves one evening observation and one noon-time observations. These can be done anytime during this week and the next. Just plan ahead so you don't run into cloudy weather on the last day of the week!

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	Day 6.2	Exam.
		Assignment: Read *Heliocentrism: Hypothesis or Truth* (ASG. Chap. 11).
	Day 6.3	Go over exam. Introduction to Copernicus' *Revolutions of the Heavenly Spheres.*
		Assignment: Finish reading *Heliocentrism: Hypothesis or Truth* (ASG. Chap. 11) and consider study questions.
Week 7 (Oct. 7, 9, 11)		
	Day 7.1	Discuss ASG Chap. 11.
		Assignment: Read *Earth as a Wandering Star* (ASG. Chap. 12).
		Laboratory: Begin *Lunar observations* (Ex. 8.4). This involves going out at the same time every evening between 8:30 and 10:30 to record your observations of the moon.
	Day 7.2	Discuss ASG Chap. 12
		Assignment: Read *Re-ordering the Heavenly Sphere* (ASG. Chap. 13) and consider study questions.
	Day 7.3	Discuss ASG Chap. 13 and Copernicus' arguments for a sun-centered world-view.
		Assignment: *Planetary Discovery* (Ex. 13.2). This is due on Day 8.2.
Week 8 (Oct. 14, 16, 18)		
	Day 8.1	Fall break
		Assignment: Re-read ASG Chap. 12 and 13 and look over notes.
		Laboratory:
	Day 8.2	Go over Ex. 13.2. Continue discussion of Copernicus' *On the Revolutions of the Heavenly Spheres.*
		Assignment: *Copernican World-view* (Ex. 13.3) and *Heliocentrism and Aesthetics essay* (Ex. 13.4). These will not be due on Day 8.3.
	Day 8.3	Go over Ex. 13.3 and 13.4. Introduction to Johannes Kepler's *Epitome of Copenican Astronomy*, in which he describes his three laws of planetary motion.
		Assignment: Read *Celestial Physics* (ASG Chap. 14) and consider discussion questions.
Week 9 (Oct. 21, 23, 25)		
	Day 9.1	Discuss ASG Chap. 14.
		Assignment: Read *Broken Spheres* (ASG Chap. 15) and consider discussion questions.
		Laboratory: Learning about (and how to set up) a Schmidt-Cassegrain telescope. Prepare for *Jupiter Observation* (Ex. 19.2).
	Day 9.2	Discuss ASG Chap. 15.
		Assignment: Type an essay on *Mind in Nature* (Ex. 16.2). This essay will be due on day 9.3. It should be single-spaced, use 12 point font, and should have correct spelling, grammar and punctuation. It should be no more than one page. Again, you should also include at least one correctly formatted citation in Chicago style at the bottom of the page. Read *Kepler's Third Law* (ASG Chap. 16) and consider discussion questions.
	Day 9.3	Discuss ASG Chap. 16.

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		Assignment: Do *Kepler's third law* (Ex. 16.1). This will not be handed in or graded. Read *Mountains on the Moon* (ASG Chap. 18) and consider study questions.
Week 10 (Oct. 28, 30, Nov. 1)		
	Day 10.1	Discuss ASG Chap. 18. Discuss how a telescope works and the concept of magnification, angular width and solid angle.
		Assignment: Do *Angular Width* (Ex. 18.1) and *Focal Length* (Ex. 18.3). These will be handed in and graded on Day 10.2. Read *The Medician Stars* (ASG Chap. 19) and consider study questions.
		Laboratory: Each group must sign up for a time during which they demonstrate that they know how to set up and polar align the telescope.
	Day 10.2	Go over Ex. 18.1 and 18.3. Discuss ASG Chap. 19.
		Assignment:
	Day 10.3	Lecture on Newton's laws of motion and Newton's theory of gravity.
		Assignment:
Week 11 (Nov. 4, 6, 8)		
	Day 11.1	Exam.
		Assignment: Read *The Luminosity of Variable Stars* (ASG Chap. 20).
		Laboratory: Each group must sign up for a time during which they demonstrate that they know how to set up and polar align the telescope.
	Day 11.2	Go over exam. Discuss ASG Chap. 20.
		Assignment: *Variability-Luminosity* (Ex. 20.1). Due on day 11.3.
	Day 11.3	Go over Ex. 20.1 Introduction to Spectroscopy and its use in astronomy.
		Assignment: Read *Galactic Spectroscopy* (ASG Chap. 21) and consider study questions.
Week 12 (Nov. 11, 13, 15)		
	Day 12.1	Discuss ASG Chap. 21.
		Assignment: *Galaxy rotation* (Ex. 21.1). Due on day 12.2.
		Laboratory: *Spectroscopy Lab* (Ex. 22.2).
	Day 12.2	Go over Ex. 21.1. Astronomical distance measurements from ancient to modern times.
		Assignment: Read *Measuring Astronomical Distances* (ASG Chap. 22).
	Day 12.3	Discuss ASG Chap. 22.
		Assignment: *Astronomical distances: stellar parallax* (Ex. 22.1) and *Astronomical distance: apparent magnitude* (Ex. 22.2). Due Day 13.1.
Week 13 (Nov. 18, 20, 22)		
	Day 13.1	Go over Ex. 22.1 and 22.2. Lecture on Einstein's theory general relativity.
		Assignment: Read *A New Theory of Gravity* (ASG Chap. 23).
		Laboratory: Early astronomical measurement

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	Day 13.2	Discuss ASG Chap. 23
		Assignment: Read *The Structure of the Universe* (ASG Chap. 26).
	Day 13.3	Discuss ASG Chap. 26.
		Assignment: *Hubble's Law* (Ex. 26.1); due Day 14.1. Read selection from
Week 14 (Nov. 25, 27, 29)		
	Day 14.1	Go over Ex. 26.1. Finish discussion Hubble's law. Introduction to Big Bang cosmology.
		Assignment: Read *Measuring the Potentially Infinite* (ASG Chap. 27).
		Laboratory: Early astronomical measurement.
	Day 14.2	Discuss ASG Chap. 27.
		Assignment: (a) *Sand Reckoning* (Ex. 27.1); due day 14.3. (b) Read *The Birth of the Big Bang* (ASG Chap. 28).
	Day 14.3	Go over Ex. 27.1. Discuss ASG Chap. 28
		Assignment: (a) *The size of the universe and big bang cosmology* (Ex. 28.3). This will not be graded. (b) Read *The Primeval Atom* (ASG Chap. 29).
Week 15 (Dec. 2, 4, 6)		
	Day 15.1	Discuss Ex. 28.3. Discuss ASG Chap. 29.
		Assignment: Read Chap. 1 of *No Free Lunch* by William Dembski.
		Laboratory: Independent observation.
	Day 15.2	Interlude on astronomy and theology: a discussion of the teleological argument.
		Assignment:
	Day 15.3	Review for final exam.
		Assignment:
Week 16 (Dec. 9 - 13): Final exams		